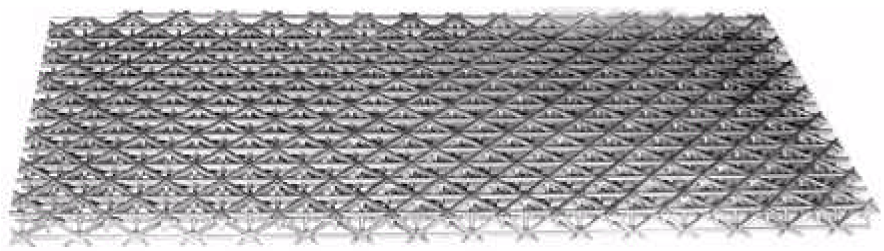
Structural Benchmark Testing of Superalloy Lattice Block Subelements Completed

A multitude of benchmark tests on superalloy lattice block structural specimens gave promising results for this new high-performance material system that utilizes alloys with a 50-plus-year history in gas turbine engine use. The testing was performed in-house at the NASA Glenn Research Center Structural Benchmark Test Facility, where the subelement-sized beam specimens were loaded at room and elevated temperatures to observe their elastic and plastic behavior, strength, and fatigue resistance.

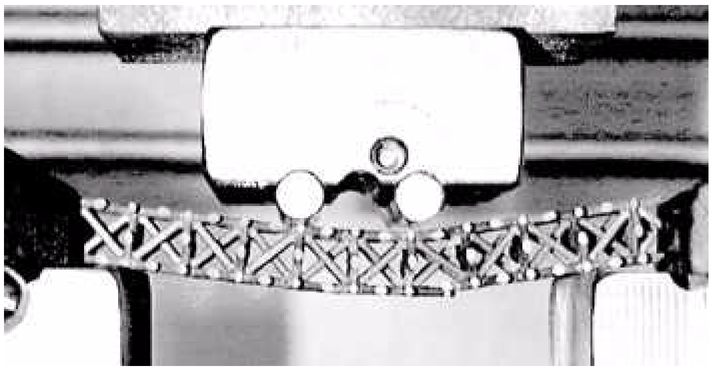


Cast Inconel 718 lattice block panel, approximately 140 by 300 by 11 mm (5.5 by 12 by 0.44 in.).

Long description. Lattice block specimen installed in test machine after bending strength test; a test photograph shows bend test specimen supported by rollers on each end and loaded near the center through two round bars. The 75-millimeter (3-inch) span has a permanent deflection of approximately 5 millimeters (0.2 inches).

Superalloy lattice block panels, which are produced directly by investment casting, are composed of thin ligaments arranged in three-dimensional triangulated trusslike structures (see the preceding figure). Optionally, solid panel face sheets can be formed integrally during casting. In either form, lattice block panels can easily be produced with weights less than 25 percent of the mass of a solid panel. Inconel 718 (IN 718) and MarM-247 superalloy lattice block panels have been developed under NASA's Ultra-Efficient Engine Technology Project and Higher Operating Temperature Propulsion Components Project to take advantage of the superalloys' high strength and elevated temperature capability with the inherent light weight and high stiffness of the lattice architecture (ref. 1). These characteristics are important in the future development of turbine engine components.

Casting quality and structural efficiency were evaluated experimentally using small beam specimens machined from the cast and heat treated 140- by 300- by 11-mm panels. The matrix of specimens included samples of each superalloy in both open-celled and single-face-sheet configurations, machined from longitudinal, transverse, and diagonal panel orientations. Thirty-five beam subelements were tested in Glenn's Life Prediction Branch's material test machine at room temperature and 650 °C under both static (see the following photograph) and cyclic load conditions. Surprisingly, test results exceeded initial linear elastic analytical predictions. This was likely a result of the formation of plastic hinges and redundancies inherent in lattice block geometry, which was not considered in the finite element models. The value of a single face sheet was demonstrated by increased bending moment capacity, where the face sheet simultaneously increased the gross section modulus and braced the compression ligaments against early buckling as seen in open-cell specimens. Preexisting flaws in specimens were not a discriminator in flexural, shear, or stiffness measurements, again because of redundant load paths available in the lattice block structure. Early test results are available in references 2 and 3; more complete analyses are scheduled for publication in 2004.



Open-cell lattice block beam specimen following strength testing in a 75-mm-span four-point bend test fixture.
Long description.

This experimental work supports the value of superalloy lattice block technology for damage-tolerant structures and for lightweight components under low and moderate pressure loadings at elevated temperatures. Potential aeropropulsion uses for this technology include turbine engine actuated panels, exhaust nozzle flaps, side-panel structures, and rotating hardware containment rings.

References

1. Hebsur, Mohan G.: Processing of IN-718 Lattice Block Castings. Processing of IN-718 Lattice Block Castings, NASA/CR--2002-211332, 2002. http://gltrs.grc.nasa.gov/cgi-bin/GLTRS/browse.pl?2002/CR-2002-211332.html

2. Krause, David L., et al.: Mechanical Testing of IN718 Lattice Block Structures. Processing and Properties of Lightweight Cellular Metals and Structures. Third Global Symposium on Materials Processing and Manufacturing, Amit K. Ghosh, T.H. Sanders, and T.D. Claar, eds., TMS, Warrendale, PA, 2002, pp. 233-242.

3. Krause, D.L., et al.: Mechanical Testing of IN718 Lattice Block Structures. NASA/TM--2002-211325, 2002. http://gltrs.grc.nasa.gov/cgi-bin/GLTRS/browse.pl?2002/TM-2002-211325.html

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